PRINCIPLES FOR THE USE OF ARTIFICIAL MATERIALS IN SOIL AMELIORATION

by

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In our previous papers we have already mentioned the well-known fact that about one half of the agriculturally used area of this country needs amelioration because of the unfavorable natural conditions, and that it is generally poor in precipitation. Therefore we explained a few theoretical and methodological basic principles for the categorization of landscapes and the usefulness of artificial materials in soil amelioration (1).

In connection with the territorial distribution of precipitation we described those agriculturally used areas of this country that need amelioration. We described the territorial distributions of the sandy, bog, alkali, and acid soils on the basis of Hahosy's precipitation chart and Mattyasovszky, Görög and Stefanovits's soil map (1).

We have already pointed out in genetically uniform areas – floodbasin micro-landscapes – which are the areas where a uniform geological base, different plant associations, and the climate are the dominant factors.

On the basis of the territorial distribution of the annual precipitation and the need of the agriculturally used areas for amelioration we classified the areas of bog, sandy, acid, and alkali soils as landscape mosaics; accordingly we divided the cropland areas of the country into landscape units using a threefold distinctions (1). Such a method is favorable for the determination in advance of the artificial materials that can be used for soil amelioration. Thus it can be clrealy determined whether in the territorial unit under examination the soil structure is to be stabilized or the air, water, or heat economy of the soil is to be *influenced* or controlled.

The advantage of the artificial materials as stabilizers over the natural structure-improvers, as humus clay, is that they do not decompose fast in the soil and that they can be applied in higher concentrations.

We have mentioned that the artificial materials and synthetic resins are chiefly organic materials with giant molecules or surface-active or nautral minerals. Their common property is that they stabilize the soil structure and influence some soil properties such as the air and water economy. We have also dealt with the polyelectrolites, synthetic material foams as well as emulsions and true solutions from the point of view of their propertires (1).

We classified the arable lands is need of amelioration in this country, because in their original state their chemical, physical, and biological properties are very different; thus we characterized them one by one from the point of view of their suitability for soil amelioration.

Nearly 3 million hectares of acid soil, 1 million hectares of alkali soil, 1,5 million of sandy soil, and nearly 100 000 hectares of bog need considerable treatment (2).

Owing to the interaction of the soil-forming factors the soils changes. The variability in time and space of its physical, chemical, and biotic complexes is due to the variety of the relations between these factors. The conditions of *termperature, water economy, aeration,* and *salt content* are of basic ecological importance on any soil. The relations of these factors determine the quality of the soil and the type of amelioration needed.

Earlier we have already said that in this country the application of artificial materials for soil amelioration both in research and practice in only beginning (2). In the following we can deal with the *theoretical use and application of methods and synthetic materials* to be proposed because it is only through expreiments that hteir application to different kinds of soil can become possible.

Amelioration of Acid Soils

In this part we deal chiefly with the amelioration of acid brown forest and acid meadow and alluvial soils.

To the first belong the nearly exclusively forested, strongly acid non-podzolic and podzolic brown forest soils. On replanting, the soil of the tree sockets dug up most be mixed to 10–15 volume per cent with open-pore (KF-piatherm foam) foams. These foams are suitable for binding water and nutrients, which the plants can take up easily from them.

We have in mind forested areas on steep slopes where the transportation of ameliorating substance and fertilizers is very expensive and difficult. Therefore it is advantageous to use foam that can be made on the site and transported artificial fertilizer concentrates.

From the point ov view of agricultural use, clayed brown forest soils are far more important. On these soils the most important thing to do is to achieve neutralization of the acidity, increase in the water absorption capacity, and protection against erosion.

Neutralization of the acidity of the soil can be effected by using the traditional liming method. The last two tasks can be achieved by more modern means and more durably.

Polyelectrolites can be used to stabilize the soil structure; open-pore KF foams to increace the water absorption capacity and to reinforce protection against erosion or to ensure a more lasting effect than with the traditional methods.

If hre „A" levels decay, the modern methods of amelioration agree practically with the above.

In *pseudogleyey brown forest soils,* which are chiefly found in Őrség, the elimination of similarly harmful properties is necessary, as in the clayed brown forest soils. In these, increasing of the water absorption capacity, decreasing of the acidity, and protection against erosion are necessary. There is no essential difference in the achievement of the last two things, but there is an essential difference in the balancing of the water economy, depending on the properties of the type in question.

Between the „A" and „B" levels there is, in this case, a gleyey layer which is impervious to water. Thus the top soil fills up very quickly with water – stagnant water – and slides down the slope, this is known as solifluxion. For leading off the excess water and stopping the sliding of the soil we suggest the application of drainage with artificial materials between the two above-mentioned levels. Knobloch's method (3) is perfectly suitable for this purpose. The reduction processes (gleying) here are already partially stopped by drainage, but deep loosening can also help.

For the rusty brown subtype of Ramann's forest soils which forms on sand we suggest the following: amelioration is generally possible as described in detail in connection with sand and/or by laying down polyelectrolites, open-pore foams, and emulsions on the surface and deeper, for instance in the form of films and „asphalt banks". Applied on the surface, these artifical materials afford excellent protection also against deflation.

We recommend the methods described in connection with sand chiefly for *sand with iron incrustation* which occurs in Nyírség and Somogy.

Meadow soils

Their characteristic in the presence of clay and heavy clay is compactness. Such soils are airless and their water: air ratio is unfavorable to microorganisms and plants. Is this case the microorganisms take even the little air away from the plants.

In the interests of successful farming these soils must be made looser and richer in air. This can be achieved in a modern way by using in addition to liming, closed-pore artificial material foams (PSfoam) containing 98% of air. These foams are quite neutral materials, not binding any water or nutrients. As they decompose very slowly, they retain their effectiveness for years. They decay in time but cavities remain in their place.

A great part of the meadow soils have a buried solonetz layer near the surface. This is an extremely compact layer which is impermeable to water, and thus stagnant water gathers in the layer over it. The stagnant waters that appear then are hindrance to agricultural cultivation. In this case the compact layer can be eliminated by loosening of the subsoil and the introduction of closed-pore artificial material foam; thus the soil becomes permeable to water and the area can be used again.

Following this, the favorable soil structure formes in the plowed layer must be stabilized with the help of polyelectrolites.

Our *alluvial soils* need structure amelioration chiefly if they were formad on carbonateless clay a very long time ago. In connection with one of our large rivers that it is of a mainly middle course type, its deposited alluvium is not clay but rathes silt – loam –. Its adhesiveness is not great, therefore its structure can be stabilized also by liming and using polyelectrolites.

If these acid, humic alluvial soils are compact clays, they must be limed and their aeration and water permeability must be secured with closed-pore artificial material foams, and the structure so formed must be preserved.

The same methods of amelioration must be employed on alluvial meadow soils if they were formed on $CaCO_3$-free material.

In the amelioration of the *alluvial soils of slopes* by means of artificial materials the decisive thing is their origin: chernozem or forest soil acid or compact layers. It is these properties that determine the necessity of liming or the manner and place of the use of the polyelectrolites. In this case, too, these last serve for preserving the structure, and the foams serve to increase the water permeability. It can happen in such cases that the water conservation of loose alluvia of light mechanical composition derived from the A_2 level of forest soils must be ensured by the sprinkling of true solutions and the development of film or hydrophobic properties.

Amelioration of Alkali Soils

We can deal with the amelioration of these soils most suitably according to Prettenhoffer's classification (4).

Non-calcic acid and near-neutral alkali soils are found chiefly east of the river Tisza. Their classical method of amelioration is liming and lime dee manuring. Our opinion is that modern amelioration should use the afore-mentioned methods, and that after the afore-mentioned methods, and that after the development of a suitable structure, polyelectrolites must also be used in order to stabilize the artificially formed soil crumbs.

The effect of the polyelectrolites can manifest itself, besides stabilization of the structure, in the fact that on decomposition of their nitrogen content-polyacrylamide, polynitrile-, they supply N to the plants.

In the Soviet Union crude oil purified from aromatic compounds is also used experimentally and with good results for the amelioration of alkali soils (5).

Non-calcic, slightly alkaline (transitional) alkali soils

These too, are chiefly found east of the Tisza. They are traditionally ameliorated with limetgypsum, black earth-acid-deep layer spreading or with gypsum-containing yellow earth. Here, too, we want to use the abovementioned materials for amelioration but with the addition that we stabilize the good soil structure that has been developed. Thus in these alkali soils we hope to remove the soluble salts and the Na ions exchanged in the course of amelioration with the help of the loosening and water permeability-enhancing effect of closed-pore foam materials.

In the case of these alkali soils we must reckon also with the colloid-precipitating effect of the considerable amount of soluble salts. It must also be taken into consideration what effect the alkaline pH has on the hydrolizing polyelectrolites.

Alkaline and calcareous sodic soils. They are found mainly in the land between the Danube and the Tisza and in smaller areas east of the Tisza. The classical method of their amelioration is the use of acid materials. In this case first of all gypsum powder and gypsum by-products of factories may come into consideration. We want to achieve the amelioration of these soils, too, by the use of the afore-mentioned materials with the addition that they would be applied in combination with artificial foams – polyelectrolites, foams, ets. – in different physical states.

On the land between the Danube and the Tisza, if the subsoil water has been regulated, these sodic soils, having generally a light mechanical composition, can be ameliorated quite deeply in a matter of a few years by gypsum treatment and the use of closed-pore artificial foams if we irrigate.

East of the Tisza the amelioration of this type of soil is much more difficult. The amelioration of larger connected areas – with the exception of the patches in the plowlands – requires much material and is still very expensive. Amelioration can therefore be carried out only in small areas at present and can be used to search for cheaper methods.

The amelioration of these areas is nearly the same as the amelioration of the sodic patches found in plowland areas, yet with this difference that in this case gypsum powder must be used as ameliorating material. Thus the good structure formed by cultivation must be preserved with the help of suitable polyelectrolites.

In connection with the amelioration of alkali soils it must be mentioned that the soil amelioration can also be done by a well-known agrotechnical method. This can be applied chiefly to soils with a „B" horizon containing but little Na; in the case of a larger Na content amelioration will be effective if simultaneously with the subsoil emelioration chemical ameliorators are introduced into the soil.

The washing out of possible Na can be facilitated by filling the interstices with artificial material foams thus hindering their closing.

The closed-pore Ps foam makes the penetration of precipitation possible thus directly promoting better leaching. On patches of alkali soil amelioration can be carried out, as explained above, according to their alkaline nature. On these patches the ameliorating materials must be spread by abundant manuring. Occasionally black earth chernozem underspreading and loosening combined with the introduction of ameliorators can be used. In order to achieve perfect amelioration it may be necessary to repeat the procedure several times. It must be noted, however, that the use of polyelectrolites on alkali soils does not always have the same effect; in case of wrong application it may be ineffective. *The effect of the polyelectrolites depends on their composition, dosage, the manner of their application, the mechanical structure and porosity of the soil, the quality of their active functional groups, the alkalinity caused by Na, the water control, etc.*

Amelioration of Sand Soils

In our previous papers we have already mentioned that a large part of the sandy areas of this country, about 3 million acres, need amelioration (6). On these soils, as is known, the unfavorable properties must first be eliminated; they are:

1. excessive water permeability, that is poor water holding capacity,
2. scarcity of nutrients,
3. tendency to deflation.

Besides the now traditional means of amelioration such as stable dung, bentonite, bog soil, peat, clay minerals, composts, green manure layer amelioration, etc., or in combination with these, we recommend the use of artificial materials, polyelectrolites, open-pore artificial resins and emulsions of the hygromull type.

The polielectrolites hinder the breakdown of organic substances in sand and their ion exchanging atom groups convey the nutrients to the plants and by their slow decomposition they may also provide nitrogen (4). To balance the nutrient economy of sands we use first of all artificial material foams and their combinations with mineral fertilizers. The KF and piatherm foams mixed with peat and artificial fertilizers are introduced into the soil by traditional means. Then they bind the water that gets into the sand and they transmit it together with the nutrients to the plants. By their slow decomposition they themelves constitute nitrogen sources (7). KF foam is used for binding and grassing sandy surfaces and sand dunes. Thus, for instance, the foamy artificial material is mixed into a kind of mush with the addition of grass seeds, mineral fertilizers, and water, and the liquid mass is then sprinkled over the area with the help of pumps. Thus the material, adhering to the soil, stores the water like a sponge later on too hinders deflation of the sand and provides a good bed for the germinating seeds (3).

All three methods are first of all aimed at *changing the unfavorable properties of the sand;* at the same time emulsions and solutions of the different materials are also used for this purpose.

a) Surface treatment

The emulsions of the different kinds of asphalt or petroleum resins and crude oil products as well as the KF foam materials must be brought on to the surface of the sand with an equipment suitable for the spraying of plant-protecting materials. However, the film that forms is pervious to water to such a degree that the soil under it can be saturated with water. The thin connected film reduces evaporation and absorbs the light rays. Owing to this, the temperature of the sand under the covered parts is higher. The film protects the seeds sown from erosion by rain and wind, but the plants coming up can break trough it easily and develop undisturbed. In general these films do not contain any nutrients for plants and so the sand soils treated in this manner must be enriched with nutrients and artificial fertilizers.

b) Deep treatment

In this case the large pore space of sands is used for stroing precipitation or irrigation water. In such a case the water-impervious layer forms under the root zone. With the help of a suitable equipment – the winged hoe – asphalt emulsion must be introduced 40 cm deep into the sand. The American machine generally lifts the soil 25 cm deep and from 26 nozzles it squirts an 85 cm wide, instantly solidifying asphalt layer. The artificial asphalt bank in the sand doubles the amount of residual water. Besides this the increase in organic substances in this layer over the years is also significant (6).

Amelioration of Bog Soils

Besides the classical methods – draining, liming, addition of nutrients, sand treatment, burning, etc. – we do not recommend amelioration of these soils with other methods or artificial materials because of the large organic matter content and the good structure. The most radical interference in the dynamics of these soils without drying them out too much is the draining of the excess water. Plowing of the topsoil, loosening, occasionally liming, manuring, and artificial breeding of the bacteria add to the effect. All these measures serve to break the predominance of reductive conditions.

For the amelioration of meadow marsches the classical methods are satisfactory with the exception of the following cases:

1. if the profile is incomplete, the „A" and „B" horizons are missing, only the gleyey mother rock the „C" horizon has remained; if this latter is $CaCO_3$-free and it is clay, then addition of closed-pore artificial material foams is necessary. In this way the aeration of overly wet soils will be ensured. At the same time the favorable structure developed by cultivation must be preserved with the help of polyelectrolites.
2. If the meadow marsh is highly acid at pH 4,5, liming adjusted on the basis of experiments is necessary.
3. If the soil of the meadow marsh is mixed with solonchak, continuous draining combined with washing trough must be ensured. If a disturbing circumstance, e. g. an intervening clay layer, hinders this, closed-pore artificial material foams must be introduced into the compact layer in order to ensure free percolation of water.
4. If the soil of the meadow marsh is mixed with solonetz, amelioration must be carried out as in the case of the alkali soils.
5. If at the surface of the soil or near to it there is a compact layer, such as a limestone bank, a cemented pebble layer, ironstone, a gleyey layer, etc. which is impervious to water, the soil becomes unsuitable for cultivation. This can be repaired by opening the way to percolating water through the introduction of chiefly closed-pore artificial material foams into this layer, if it is feasible at all.

The above-described method must be used also in analogous cases of drained and tilled meadow marsh soils.

In the literature mechanical, chemical, and biological methods are recommended for the amelioration ot the oxygen economy of bog soils (5). Surveying the different methods we see that we can deal only with the amelioration of such soils as constitute about 40% of our agriculturally productive areas. We have not dealt with the preservation of the structure of our best soils, the chernozems and the barren stony, rocky, mining waste tip areas.

We think that the use of artificial materials in the afore-mentioned areas will be of great importance in the near future. It is not meant that only the methods of amelioration described here can be used for the different types of soils, but that the methods indicated should be considered in preference to other methods. In every case it is the environmental factors, physical, chemical, and biological properties of the soil that determine the method of amelioration.

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